CAUSES:

Clouds Above the United States and Errors at the Surface

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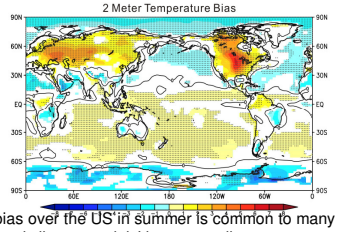
1) CAUSES:

"A project with an observationally-based focus, which evaluates the role of clouds, radiation and precipitation processes in contributing to the surface temperature biases in the central US and which are seen in several weather and climate models."



The warm bias over the US in summer is common to many GCMs. It is seen in several climate models' long-term climate mean and it shows up as a bias within a few days when running climate models from analysis in NWP mode.

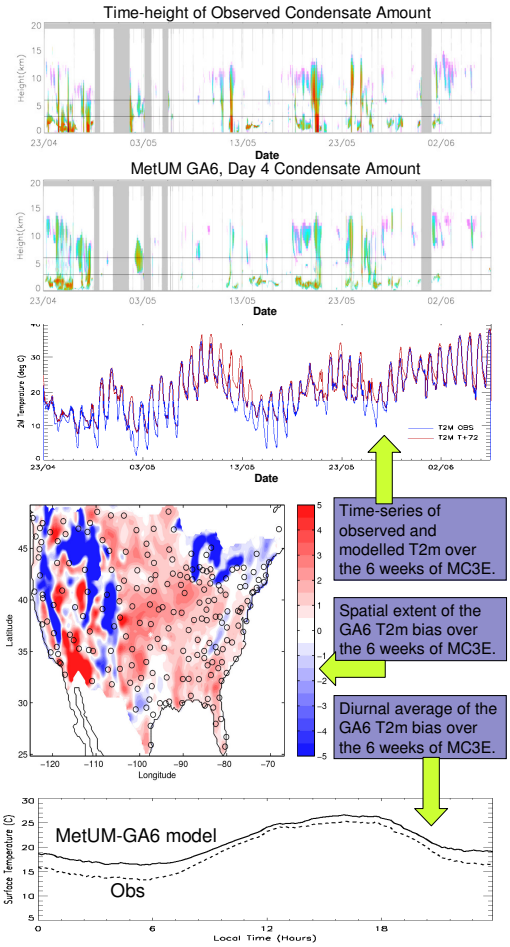
2) Region and Period of Analysis

- The investigation will focus on the American mid-west and use observations from the **SGP** site (36.61 N, 97.49 W).
- We focus on the warm season of 2011, which at its start featured a major ARM field campaign: the Midlatitude Continental Convective Cloud Experiment (**MC3E**, 22 April to 6 June 2011).

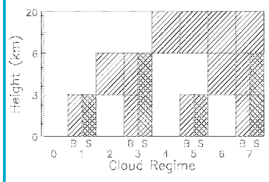
3) Model Simulations

- All models to be run in weather forecasting (NWP) mode.
- Models to be run out to T+96, with daily re-initialization from analyses (i.e. ECMWF, 00Z analyses).
- Running each simulation for 4 days, allows us to look at the growth of the errors as a function of lead time.

We demonstrate our method using data from Met Office Unified Model (GA6 configuration, with dx=30 km over SGP, use data from "day 4").



4) But how do we determine whether errors in the clouds predictions are the causes of errors in the screen-level temperature?

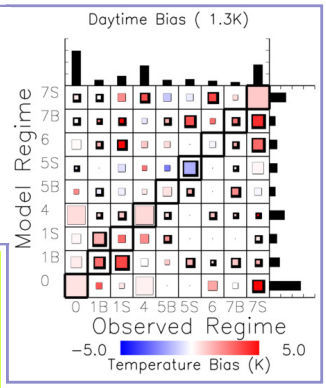


Use 3 height ranges. Define 8 regimes based on all permutations of cloud occurrence. Also split 4 regimes involving low cloud into a "broken" and "stratiform". This gives us 12 possible regimes.

5) For each hour in the 6 weeks of MC3E, compare the modelled and observed regime.

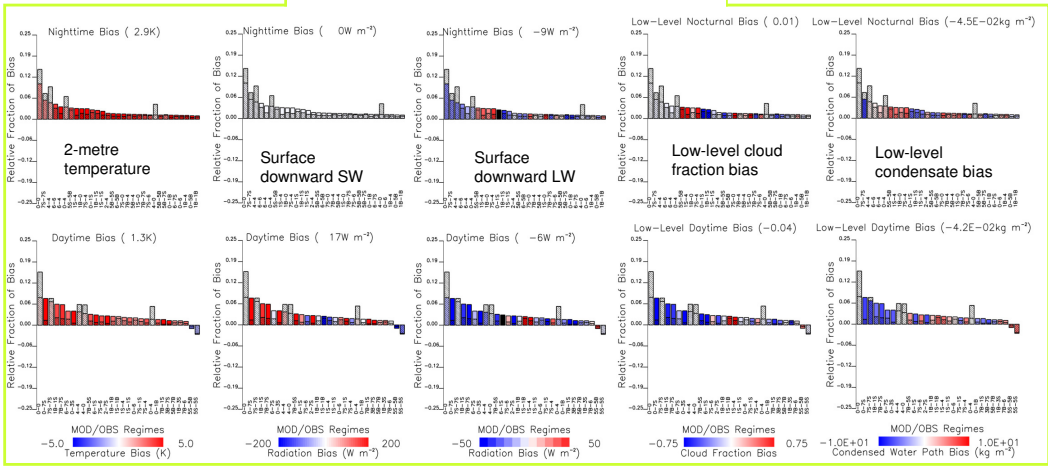
This gives us 144 regime permutations. Then average the T2M bias for each permutation and plot it on contingency table. Infrequent regimes are not plotted.

- Size of square scales with frequency of occurrence of regime combination.
- Shading indicates magnitude of the bias (T2m in this case).
- Shadow is present when regime combination is statistically significant.

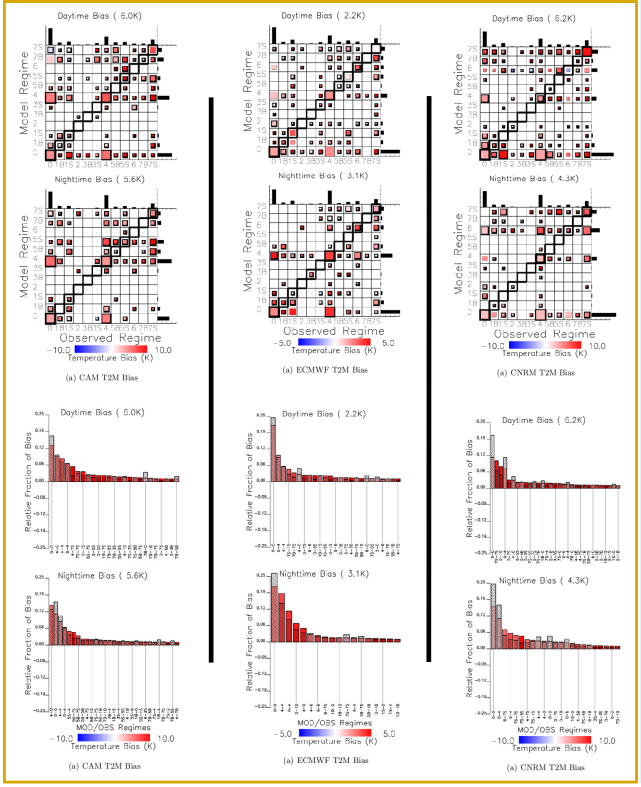


6) Now rank the regime combinations based on their contribution to the overall temperature bias (height of shaded bar).

For each variable, the bias in a given regime is product of contribution from frequency of occurrence (hatched bars) and mean bias in that combination (colour shading).
For **Met Office Unified Model (MetUM)** (day 4):



7) Other models (Day 3)



8) Results

- MetUM-GA6: (bias bigger at night)
  - day-time, missed-deep cloud (0-7S) only occurs ~1% of the time but T error is so large it leads to 8% of the bias.
  - (1B-1S) 2% of the time, but 6% of the bias. Cloud fraction is too low and LWP is as well.
- CAM5: (bias about the same day & night)
  - (4-4) poorly represented cirrus even when present.
  - (0-4) missing cirrus.
  - (4-7S) anvils without accompanying low & mid.
- ECMWF (bias bigger at night)
  - Night-time, significant bias when model misses cirrus (0-4) but also when it does capture it (4-4).
  - Day-time: (1S-1S) regime "Sc" is leading cloud problem area. Then its broken rather than stratiform deep cloud (7B-7S).
- CNRM (bias bigger during the day)
  - Leading cloud issue during the day is poorly-represented deep (convective) cloud (7S-7S) and missed stratiform low cloud (0-1S).

9) Future Work

- Evaluate other models.
- Look at SW, LW, LWP, IWP, CF biases for all models.
- Perform off-line land-surface sensitivity tests.
- Perform some convection-permitting (dx~1km) simulations and some longer seasonal runs.
- Repeat the analysis having made some parametrization changes.
- Write some papers!

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The "CAUSES" project is a collaboration between GASS and ASR, led by staff at the Met Office and PCMDI.
Please get in touch if you would like to participate.